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United States
Department of
Agriculture

Forest
Service

Cooperative
State Research
Service

Agriculture
Handbook No. 615

Spruce Budworms Handbook

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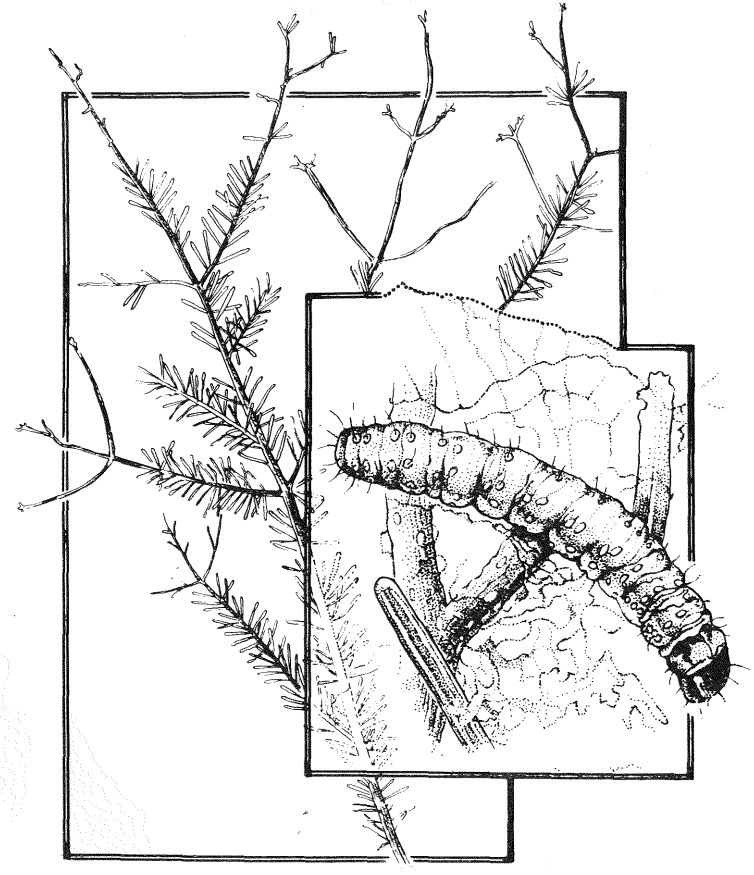
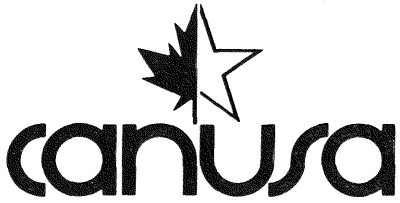
#460

Insecticides for Control of the Spruce Budworm



In 1977, the United States Department of Agriculture and the Canada Department of the Environment agreed to cooperate in an expanded and accelerated research and development effort, the Canada/United States Spruce Budworms Program (CANUSA), aimed at the spruce budworm in the East and the western spruce budworm in the West. The objective of CANUSA was to design and evaluate strategies for controlling the spruce budworms and managing budworm-susceptible forests, to help forest managers attain their objectives in an economically and environmentally acceptable manner. The work reported in this publication was wholly or partially funded by the Program. This manual is one in a series on the spruce budworm.



Canada
United States
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February 1984

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Insecticides for Control of the Spruce Budworm

by

Bruce A. Montgomery, John B. Dimond, John A. Witter, and Gary A. Simmons[1]

Introduction

Over the last 30 years the spruce budworm, *Choristoneura fumiferana* (Clemens), has defoliated and killed a large number of spruce–fir stands in Maine, Minnesota, Michigan, Wisconsin, New Hampshire, and Vermont. Maine's economy is heavily dependent on spruce–fir; the State has sprayed insecticides since 1954 to keep trees alive. By contrast, forest owners and managers in the Lake States generally have not applied insecticides for spruce budworm control due to poor markets for spruce and fir timber. However, new and improved markets may necessitate protecting this resource in the 1980's.

This handbook is for forest entomologists, biologists, and extension workers who have responsibilities to forest managers that could include making recommendations on the use of insecticides. Because rates of application are given as ranges and because registrations change, actual pesticide labels must be used as the final source of information.

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Life Cycle

The spruce budworm has one generation per year. Figure 1 shows the annual cycle of the budworm. Minor variations in this cycle are due to weather conditions (cool temperatures retard development) and forest conditions (a surplus of host-tree flowers and new shoots accelerates development).

A budworm larva molts five times, growing in length from 0.08 to 1.2 inches (2 mm to 3 cm). Between molts, the budworm is called an instar. The second instars overwinter on host trees and begin feeding inside old needles in late April and early May. The third instars move from the old needles to feed inside unopened, swelling buds. Thus, the first two larval stages that appear in the spring are largely protected. The fourth, fifth, and sixth instars feed in the open on new foliage during late May and June. The sixth instars account for over 80 percent of the total foliage consumed. The resting or pupal stage occurs for 2 weeks in late June or early July; then moths emerge, mate, and lay eggs in July and early August. Each female lays about 200 eggs, from which first instars hatch in August. The first instars do no substantial feeding. Rather, they just crawl about on foliage and twigs and then spin silken cases and hibernate for the winter.

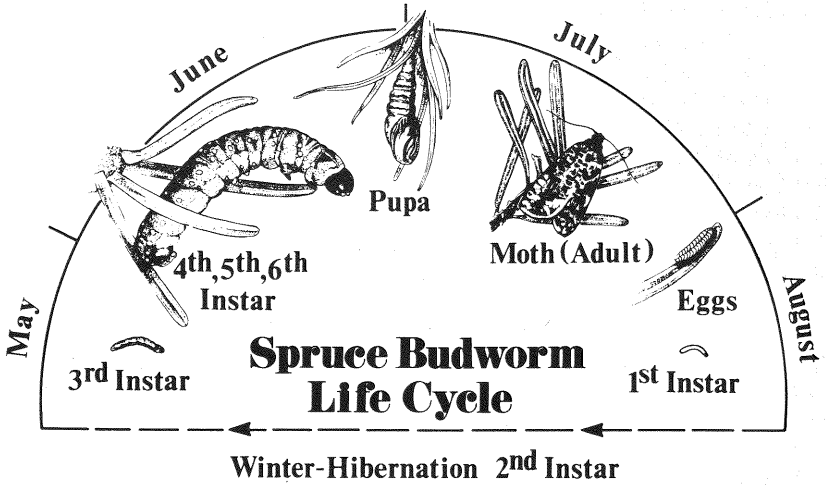

Figure 1—The life cycle of the spruce budworm. (This illustration and cover art by Kathy Simpson, The University of Michigan, Ann Arbor.)

Deciding to Spray

The objective of spraying insecticides is to reduce the number of larvae so that excessive defoliation is prevented and trees are kept alive and growing. To determine if a spruce–fir stand should be treated with insecticides, a landowner should

1. Establish management objectives and planned production goals for each stand. Spruce–fir stands that are scheduled for use or harvest may need protection during a spruce budworm outbreak. Stands that are not critical to the owner can be designated ''no-spray'' areas and would not be treated with insecticides.

2. Estimate the potential effect of a spruce budworm outbreak on each ''scheduled'' stand. During an outbreak, severe defoliation may occur in any spruce–fir stand. However, tree mortality is likely to be greatest in stands with a high percentage of balsam fir trees 50 years or older. To estimate potential mortality, use a hazard-rating system such as the one developed by Batzer and Hastings (1981) for Minnesota.

3. Determine whether preventing severe defoliation or tree mortality would be worth the costs of spraying insecticides. Several points should be considered when making this decision. First, stands that are scheduled for harvest within 5 years should not be treated with insecticides. Second, spraying insecticides may keep a stand in a vulnerable condition. Experience shows that a stand once sprayed with insecticides must be resprayed in 3 to 5 years because budworms from unsprayed areas can reinfest treated stands. Third, the cumulative effect of repeated spraying of chemical insecticides on the environment is not completely understood. Finally, monetary costs incurred in protecting timber crops will not be returned until harvest.

4. Monitor the number of budworms and level of damage. This helps identify the boundaries and intensity of an outbreak. Severe defoliation (75 percent or greater loss of new needles) for 4 or 5 consecutive years results in mortality of balsam fir. It takes 6 or more years of severe defoliation to initiate spruce mortality. Treatments with insecticides should begin after 2 years of severe defoliation.

Management responses to the most recent spruce budworm outbreaks have varied widely from area to area and year to year. Variations are based on the importance of forest industry to an area's economy, and on different patterns of landownership, timber supply levels, attitudes toward spraying, and levels of importance of fir and spruce resources to local industry (Irland 1980).

Once a spruce budworm outbreak occurs, there are three general options: (1) harvest the stand, (2) allow the budworm to harvest the stand, or (3) treat with insecticides. Option 1 usually involves the removal of all ma-

Costs

ture host trees in a single cut (Flexner et al. 1983). Option 2 is a wait-and-see approach. If a scheduled stand cannot be harvested or sprayed, the budworm population may naturally decline and leave a stand without too much damage. Generally, however, this is not the case. Fir mortality ranges from 70 to 100 percent in mature and overmature stands and from 30 to 70 percent in immature stands. Mortality of mature white spruce ranges from 10 to 40 percent, and mortality of black spruce is even less.

Option 3 is sometimes implemented when an infested stand is critical to the owner but cannot be harvested within 5 years. Maine's extensive forest-protection policy is to spray when necessary to prevent tree mortality and, in some areas, to maintain tree growth. Short-term spray strategies are designed to save the most valuable mature spruce–fir stands that have had greater than 75-percent defoliation for 2 years. Merchantable mature trees usually are not sprayed if landowners plan to harvest them within 5 years.

Spraying may be appropriate in vigorous, young stands with good growth potential. For example, spraying might be done in a 20- to 40-year-old stand with an infestation level around 15 larvae per 18-inch (45-cm) branch. Such a program should limit defoliation to 35 percent, thus sustaining good tree growth through the end of the rotation.

Spray costs may range from $5 to $20 per acre ($12 to $50 per ha), depending on the insecticide used, method of application, size of the area to be treated and its distance from airfields, rates charged by the applicator, and other factors. Expenditure trends since 1976 for the State of Maine's spruce budworm suppression project are presented in table 1. Data in tables 2 and 3 are based on Maine's 1981 1-million-acre (404,700-ha) spray project. Economics of scale should be considered when using these estimates as guidelines for smaller projects. Also, environmental monitoring was conducted in each sprayed area, adding a substantial increment to the large helicopter cost in particular. Capital charges for past investments (e.g., tanks, pumps) and certain fixed costs (e.g., airbases, program overhead) are not included. Factors such as ferrying distances, load capacity, weather, block size and design, and the spray volume per acre have substantial effects on choice of aircraft and estimated costs.

In 1982, the State of Michigan aerially sprayed a chemical insecticide (carbaryl) on 3,800 acres (1,538 ha) of timberland and on two 4-acre (1.6-ha) campgrounds to suppress outbreaks of the jack pine budworm, *Choristoneura pinus* Freeman. Approximate costs for these spray operations are presented in table 4.

Table 1—Expenditure trends[1] per acre for Maine spruce budworm suppression project, 1976–81 (U.S. Department of Agriculture, Forest Service 1982*b*)

Item	1976	1977	1978	1979	1980	1981
			Dollars			
Aircraft	.68 (1.68)[2]	.98 (2.42)	1.01 (2.50)	1.29 (3.19)	2.59 (6.40)	1.85 (4.57)
Insecticide	1.59 (3.93)	1.70 (4.20)	1.86 (4.60)	1.99 (4.92)	2.33 (5.76)	2.34 (5.78)
Fuel oil (carrier)	.02 (.05)	.02 (.05)	.02 (.05)	.04 (.10)	.04 (.10)	.06 (.15)
Food and lodging	.01 (.02)	.08 (.20)	.07 (.17)	.07 (.17)	.17 (.42)	.23 (.57)
Temporary labor	.01 (.02)	.12 (.30)	.05 (.12)	.19 (.47)	.30 (.74)	.82 (2.03)
Environmental/ health monitoring	— (—)	.05 (.12)	.04 (.10)	.06 (.15)	.16 (.40)	.14 (.35)
Mixing and loading	.09 (.22)	.14 (.35)	.14 (.35)	.08 (.20)	.31 (.77)	.35 (.86)
Miscellaneous[3]	.02 (.05)	.12 (.30)	.09 (.22)	.16 (.40)	.19 (.47)	.38 (.94)
Total	2.42 (5.97)	3.21 (7.94)	3.28 (8.11)	3.88 (9.60)	6 .09 (15.06)	6.17 (15.25)

[1]Definitions of cost components have changed over time, causing some variation in cost.
[2]Dollars per ha in parentheses.
[3]Includes security, travel, and communication.

Table 2—Estimated cost per acre of insecticides used in Maine 1981 spruce budworm suppression project[1]

Item	Fixed-wing aircraft			Helicopter	
	Grumman PV-2	McDonnell-Douglas C-54	Cessna Thrush	Bell 206	Bell G-5
Insecticide capacity (gal)[2]	1200 [3](4542)	2400 (9084)	300 (1136)	350 (1325)	50–80 (189–303)
Average ferry distance (miles)	40 [4](64.4)	40 (64.4)	10 (16.1)	3 (4.8)	3 (4.8)
Sevin-4-oil 0.75 lb in 30 oz/acre[5] (dollars)	4.18 [6](10.33)	4.18 (10.33)	3.60 (8.90)	6.27 (15.49)	6.12 (15.12)
Orthene 0.5 lb in 64 oz/acre[7] (dollars)	7.72 [6](19.08)	7.72 (19.08)	6.47 (15.99)	8.26 (20.41)	— —
Thuricide 16B 8 BIU in 80 oz/acre[8] (dollars)	10.48 [6](25.90)	10.48 (25.90)	8.92 (22.04)	10.30 (25.45)	12.35 (30.52)

[1]Adapted from the CANUSA data fact sheet "Estimating Spruce Budworm Spray Costs" (USDA Forest Service 1982*a*).
[2]Actual capacities may vary with insecticide weight and operating conditions (e.g., altitude, runway length).
[3]Liters in parentheses.
[4]Kilometers in parentheses.
[5]841 g in 2.2 l/ha. Cost of split applications at 30 oz/acre (2.2 l/ha) is about 50 percent higher for all aircraft.
[6]Dollars per ha in parentheses.
[7]560 g in 4.7 l/ha.
[8]20 billion international units (BIU) in 5.8 l/ha. Cost of regime of 12 BIU in 96 oz/acre (30 BIU in 7.0 l/ha) is 25 to 30 percent higher for all aircraft.

Table 3—Cost per acre for selected treatments, Maine 1981 spruce budworm suppression project[1]

Item	Sevin-4-oil[2]		Thuricide 16B[3]	
	Cessna Thrush	Bell G-5 helicopter	Cessna Thrush	Bell G-5 helicopter
	Dollars			
Insecticide	[4]2.52 (6.23)	2.51 (6.20)	5.17 (12.78)	5.19 (12.82)
Aerial application	0.76 (1.88)	1.84 (4.55)	2.05 (5.07)	4.08 (10.08)
Mixing and loading	0.14 (0.35)	0.18 (0.44)	1.52 (3.76)	1.48 (3.66)
Monitoring, administration, aircraft, security, Medevac	0.18 (0.44)	1.59 (3.93)	0.18 (0.44)	1.60 (3.95)
Total	3.60 (8.90)	6.12 (15.12)	8.92 (22.05)	12.35 (30.51)

[1]Adapted from the CANUSA data fact sheet "Estimating Spruce Budworm Spray Costs" (USDA Forest Service 1982*a*).
[2]0.75 lb in 30 oz/acre or 841 g in 2.2 l/ha.
[3]8 BIU in 80 oz/acre or 20 BIU in 5.8 l/ha.
[4]Dollars per ha in parentheses.

Table 4—Estimated cost per acre for Michigan 1982 jack pine budworm suppression project[1]

Item	3,800-Acre (1,538-ha) spray block	Two 4-acre (1.6-ha) campgrounds
	Dollars	
Insecticide[2]	[3]4.18 (10.33)	4.18 (10.33)
Fuel oil	0.30 (0.74)	0.30 (0.74)
Aircraft	2.75 (6.80)	10.00 (24.71)
Administration[4]	1.50 (3.71)	1.35 (3.34)
Total	8.73 (21.58)	15.83 (39.12)

[1]Source: personal communication from Ronald Murray, Forest Pest Specialist, Michigan Dept. of Natural Resources, Roscommon, Mich.
[2]Carbaryl (Sevin-4-oil) at 0.75 lb in 32 oz/acre (841 g in 2.34 l/ha).
[3]Dollars per ha in parentheses.
[4]Includes travel, communication, labor, and guide plane.

The Work Plan

Where control by insecticides is feasible, a work plan should be developed. A plan makes spraying operations more efficient and organized, and helps ensure the safety of project personnel. Depending on the owner and the complexity of the project, the work plan should describe or identify some or all of the following:

- The target and pest.
- The insecticide to be applied and its signal class.
- The mixing and loading procedures and area.
- The method of application and equipment to be used.
- The time schedule for the application.
- A means for assessing the impact of the treatment on the budworm population.
- A means for disposing of insecticide containers.
- Safety procedures that must be followed (*see* Singer [1980] for details).

For private landowners, work plans can be relatively informal; they are often used for accounting and record-keeping. If Federal funds are included in the program, the work plan is more formal, beginning with an environmental analysis. If the analysis indicates that the spray operation may have significant environmental impacts, then an Environmental Impact Statment (EIS) is required. The EIS formally documents the details in the work plan.

What You Can Spray

Table 5 lists the insecticides that are registered by the U.S. Environmental Protection Agency (EPA) for control of spruce budworm.[2] Registrations of insecticides are under constant review by the EPA, so the user should consult with extension specialists, manufacturers, or State and Federal authorities if help is needed in selecting an insecticide for budworm control. State and local restrictions and ordinances must also be met before spraying can begin. For additional information, contact pesticide specialists with the USDA Forest Service or your State (*see* p. 26).

In table 5, all insecticides except methomyl are "general use" pesticides, that is, they can be purchased and used by the general public. Methomyl is a "restricted use" pesticide; it can be used only by certified applicators or persons under their direct supervision.

Pesticide labels must be the final source of information to protect both the applicator and the environment. It is illegal to apply pesticides at dosages that exceed recommended rates. In addition, excessive dosages of chemical insecticides can be phytotoxic, killing the trees that are being "protected." Labels are legal documents that must be followed when using a pesticide. There are both civil and criminal penalties for using a pesticide in a manner that does not conform to label statements. Judgment must rule in certain cases; for example, the Federal Insecticide, Fungicide, and Rodenticide Act, as amended (U.S. Environmental Protection Agency 1978), specifies that a pesticide can be applied to any crop listed on the label. The target pest does not have to be listed.

[2] Futura (EPA registration number 43382-13), a B.t. product of Biochem, was registered in November of 1983, after this handbook was submitted for publication. Futura is a liquid formulation with a guaranteed potency of 54.5 BIU/gal (14.4 BIU/l). For more information, consult the label.

Table 5 —Application guide for commonly used chemical and microbial insecticides registered for spruce budworm control in the United States[1]

Common name, trade name, and EPA registration number	Formulation[2]	Dilution[3]	Application	Remarks
Acephate				
Orthene Forest Spray 239-2443	75% SP	2/3 lb + 1/2 gal water	Aerially apply 1/2 gal per acre.	Treat 4th and 5th instars.
Aminocarb				
Matacil 180 Flowable 3125-327	F	Dilute in sufficient diesel or fuel oil for a total of 29–32 fl oz/acre.	*Single application:* Apply 12.8 fl oz/acre. *Split applications:* Apply two applications of 5-1/3 fl oz/acre, 5–6 days apart.	Treat 4th and 5th instars in New England States. (Can be used in NJ, NY, PA, and all New England States.)
Bacillus thuringiensis (B.t.)				
Bactospeine 43382-5	FC	1 qt + 100 gal water 1 qt + 1/2–10 gal water/acre	Ground spray Aerial application	Use against populations below 35 larvae/18-inch branch tip.
Bactospeine 43382-2	WP	1–2 lb + 100 gal water 1–2 lb + 1/4–10 gal water/acre	Ground spray Aerial application	Use against populations below 35 larvae/18-inch branch tip. Treat 3d and 4th instars.

Common name, trade name, and EPA registration number	Formulation[2]	Dilution[3]	Application	Remarks
Dipel 4L 275-36	L	2 pt + 10–100 gal water 2 pt + water	Ground spray Aerial application	Use greater rates in northern States. Tank mix ratio must be no less than 50:50.
Thuricide 16B 11273-11	L	1-1/2–2 qt + 10–100 gal water 1-1/2–2 qt + water	Ground spray Aerial application	Treat 3d and 4th instars. Use a minimum of 20% water in spray mix per acre. Treat 3d and 4th instars.
Thuricide 24B 11273-29	L	2–3 pt + water to achieve at least 1/2 gal/acre	Aerial application	Apply to dry foliage; consider bud cap opening. Treat 3d and 4th instars.
Thuricide 32LV 11273-35	L	24–48 oz + 10–100 gal water/acre 24–48 oz + least 1/2 gal water/acre	Ground spray Aerial application	Wet foliage short of excessive runoff. Apply to dry foliage when larvae are in 3d and 4th instars.

Table 5—Continued

Common name, trade name, and EPA registration number	Formulation[2]	Dilution[3]	Application	Remarks
Thuricide 48LV 11273-42	L	16–44 oz + 10–100 gal water/acre	Ground spray	Wet foliage short of excessive runoff.
		16–44 oz alone or with water at 32–128 oz/acre	Aerial application	Apply to dry foliage when larvae are in 3d and 4th instars.
Carbaryl				
Sevimol 4 264-321	L	1 qt + 100 gal water	Ground spray	Treat 4th and 5th instars.
		1 qt + water	Aerial application	Use sufficient water for coverage.
Sevin-4-Oil 264-323	L	Equal parts Sevin-4-Oil + diesel fuel or kerosene	Ground spray 0.8 pt/acre	Cover foliage thoroughly.
		1 qt undiluted or 24 fl oz + 6 fl oz of fuel oil	Aerial application	For foliage protection. Treat 4th and 5th instars.

Common name, trade name, and EPA registration number	Formulation[2]	Dilution[3]	Application	Remarks
Sevin Sprayable 264-316 Sevin XLR 264-333 Sevin SL 264-335 Sevin FR 264-345	L	1 qt + 100 gal water	Ground spray	Apply to 4th and 5th instars.
		1 qt + water	Aerial application	Use sufficient water to provide thorough coverage.
Fenitrothion				
Sumithion 8 E 39398-3	81% EC	10.4 gal + water to make 100 gal spray	Aerial application	Apply 0.15 gal (2 oz a.i.) per acre to 4th and 5th instars in two successive applications.
Sumithion Concentrate 476-2819	EC	15.6 gal + water to make 100 gal spray	Aerial application	Apply 0.15 gal (3 oz a.i.) per acre to 4th and 5th instars.

Table 5—Continued

Common name, trade name, and EPA registration number	Formulation[2]	Dilution[3]	Application	Remarks
Malathion				
Cythion Ultralow Volume 241-208 Malathion ULV Concentrate 241-110 Malathion ULV Concentrate 904-243	ULV	95% ULV undiluted	Aerial application	Apply 13 fl oz/acre. Use special nozzles for low-volume application; apply when most larvae are in 5th instar.
Methomyl				
Nudrin 1.8 201-347	L	1.8 lb a.i./gal	1–2 pt + 100 gal water	Ground spray when larvae are actively feeding. Respray after 3–4 days if needed. **Restricted use:** To be applied by certified applicators only.
Nudrin 90 201-324	90% SP	1/4–1/2 lb/acre + water	Aerial application	Use a minimum of 5 gal water/acre.

Common name, trade name, and EPA registration number	Formulation[2]	Dilution[3]	Application	Remarks
Methoxychlor				
Methoxychlor 2EC 279-2685 50W Methoxychlor 904-217	EC WP	2 lb a.i./gal	1–2 qt + 100 gal water	Ground spray to early instars or when insects first appear; approximate rate is 2 gal/acre.
Mexacarbate				
Zectran DB 264-385	L	Dilute with kerosene, diesel fuel, or No. 2 fuel oil in sufficient volume to provide adequate coverage.	*Single application:* Apply 8.8 fl oz/acre. *Split applications:* Apply twice at 4.4 fl oz/acre (0.125 lb a.i./acre) each time.	Treat 4th and 5th instars. Aerial application only.
Naled				
Dibrom 8 239-1281	EC	8 lb a.i./gal	1 pt + 100 gal water	Ground spray at first signs of insect; repeat as necessary.

Table 5—Continued

Common name, trade name, and EPA registration number	Formulation[2]	Dilution[3]	Application	Remarks
Trichlorfon				
Dylox 4				Aerially apply for foliage protection; treat when 50% of larvae are in 4th instar. Restricted use in Maine only.
3125-210	ULV	Undiluted	1–2 pt/acre ULV	

[1]Adapted from Hamel 1981 and the CANUSA data fact sheet "Insecticides for Spruce Budworm Control" (USDA Forest Service 1982*a*) and insecticide labels themselves.

[2]Formulation abbreviations: L = liquid, SP = soluble powder, EC = emulsifiable concentrate, FC = flowable concentrate, WP = wettable powder, ULV = ultralow volume, F = flowable.

[3]To calculate metric measurements, use these equivalents:

1 ounce (oz) = 28.3495 grams (g)	1 lb/gal = 119.8 g/l
1 pound (lb) = 0.454 kilogram (kg)	1 fluid ounce (fl oz) = 29.573 milliliters (ml)
1 gallon (gal) = 3.785 liter (l)	1 acre = 0.405 hectare (ha)
1 quart (qt) = 0.946 l	1 unit/acre = 2.471 units/ha
1 pint (pt) = 0.473 l	

B.t. or Chemical Insecticides?

Bacillus thuringiensis (B.t.), a biological insecticide, is a credible alternative to chemical insecticides. When B.t. is applied correctly, it is as effective against budworms as most chemical insecticides. Special adaptation of aerial or ground equipment is not required for B.t.

There are several differences between B.t. and chemicals:

- B.t. is not toxic to humans.
- B.t. is not toxic to predators and parasites that aid in suppressing the budworm population.
- B.t. is environmentally and ecologically less destructive than chemical insecticides (Dubois and Lewis 1981).
- B.t. is readily available but costs more than chemical insecticides. With increasing B.t. use and production, this cost difference has been decreasing over the last few years.
- B.t. has to be eaten by the larvae and is slower acting than chemical insecticides. Unlike chemical insecticides, B.t. has no knockdown effect. Timing of application is more critical with B.t.

Timing of Sprays

Two factors determine the timing: the degree of foliage expansion and the stage of larval development. Unless insect numbers are excessive—meaning more than 35 larvae per 18-inch (45-cm) branch—spraying should be delayed until the new shoots have elongated 0.5 to 0.75 inch (1.2 to 1.8 cm). At this length the new needles start to spread laterally, providing a suitable receiving surface for the spray and corresponding with the time that most of the larvae are fourth instars. Weather permitting,

- Spray chemical insecticides when most larvae are fourth or fifth instars.
- Spray B.t. when most larvae are third or fourth instars.
- Do not spray when larvae are in the second instar because at this needle-mining stage they are relatively inaccessible to sprays.

In addition to larvae being protected from sprays during needle mining, there is the problem of the persistent bud scale cap on white spruce and red spruce. Split applications of insecticides may be appropriate when spruce is an important target; the second application should be made after bud caps have fallen.

A split application may also be used against high budworm populations in fir stands. Areas are sprayed twice, about 1 week apart. Although split

Christmas Trees and Ornamentals

applications are effective, the extra cost must be justifiable.

Large-scale insecticide programs for areas extending over several thousand to several million acres often require split applications. There are simply too many stands to be sprayed with a single application during the optimum time—the 5 to 10 days when larvae are fourth and fifth instars. Stands sprayed when larvae are second and third instars must be resprayed.

Christmas trees are not likely to be killed by budworm, but they can sustain enough damage to cause downgrading. To prevent noticeable defoliation, treatment of Christmas trees and similar-size ornamentals must take place earlier in the year or earlier in the outbreak than is required to protect mature stands. When spruce budworm populations are common in a region, around 100 buds should be examined as soon as they begin to open in May. Choose only a few buds per tree and try to examine trees from all parts of the plantation or stand. Divide the total number of larvae found by the total number of buds examined. Table 6 is a general guide for deciding if action should be taken.

The decision to spray insecticides rests with the plantation owner or homeowner. The current conditions of the stand should be considered carefully. Poor-quality trees probably should be protected at a lower threshold than high-quality trees, because slight additional damage could reduce grade more significantly in poorer quality trees.

On spruce, bud caps protect the larvae throughout most of the feeding period. Use a hydraulic sprayer at very high pressure and apply materials twice—at budbreak and 10 to 15 days later.

On fir, a single application of an insecticide 10 to 15 days after budbreak usually is sufficient. A mist blower can be used on fir because budworms are not protected by bud caps.

Table 6—Spruce budworm population levels where damage is expected to result in reduced grade on Christmas trees (Simmons 1982)

Species	Suggested action threshold[1]	
	4 years or more from harvest	3 years or less from harvest
Black spruce	Does not apply; highly resistant to spruce budworm	Does not apply; highly resistant to spruce budworm
Spruce Black Hills Engelmann Norway Serbian White Douglas-fir	0.2 to 0.4 larvae/bud	0.1 to 0.2 larvae/bud
Fir Balsam Concolor Fraser	0.1 to 0.2 larvae/bud	0.05 to 0.1 larvae/bud

[1] Individual circumstances may warrant using different values.

Spray Equipment and Calibration

Effective coverage of trees and stands with an insecticide requires proper selection and calibration of spray equipment. Refer to the label for guidance. Stands up to 10 acres (4 ha) can be sprayed adequately with portable mist blowers at a rate of 5 to 10 gallons liquid spray per acre (47 to 94 l/ha). No attempt should be made to wet the foliage with **concentrated** sprays applied with mist blowers.

Less concentrated formulations (32 fl oz a.i. in 100 gallons water, or 1 l a.i. in 400 l water) can be applied with hydraulic sprayers on small forested areas. Apply 125 gallons of the **dilute** solution per acre (1,170 l/ha), wetting the foliage completely.

Larger areas with suitable access can be treated with a sprayer mounted on a truck or tractor. Spraying with fixed-wing airplanes or helicopters is effective on areas as small as 4 acres (1.5 ha). Boom and nozzle equipment is the predominant system used in Maine, with rotary atomizers used for some applications. Equipment calibration is discussed in detail by Bohmont (1981).

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Pesticide Specialists

State Entomologist
Maine Bureau of Forestry
State House Station 22
Augusta, ME 04333
(207) 289–2791

Director of Survey and Assessment
Maine Bureau of Forestry
Airport Road
Old Town, ME 04468
(207) 827–7221

Supervisor of Product Registration Division
Michigan Department of Agriculture
Plant Industry Division
P.O. Box 30017
Lansing, MI 48909
(517) 373–1087

Agricultural Chemical Supervisor
Minnesota Department of Agriculture
Agronomy Service
90 West Plato Boulevard
St. Paul, MN 55155
(612) 296–8547

Chief of Bureau of Forest Resource Management
N.Y. State Department of Environmental Conservation
50 Wolf Road
Albany, NY 12233
(518) 457–7370

Pesticide Coordinator
USDA Forest Service
Northeastern Area
State and Private Forestry
370 Reed Road
Broomall, PA 19008
(215) 461–3153

Chief of Forest Resource Protection
Department of Forests, Parks, and Recreation
Division of Forestry
Heritage II. 79 River Street
Montpelier, VT 05602
(802) 828–3471

Extension Specialist
Extension Service, Department of Entomology
Nesmith Hall
University of New Hampshire
Durham, NH 03824
(603) 862–1159

Regional Pesticide Coordinator
USDA Forest Service
Aviation and Fire
633 West Wisconsin Avenue
Milwaukee, WI 53203
(414) 291–1899

Chief of Pesticide Use and Control
Wisconsin Department of Agriculture
Trade and Consumer Protection
Plant Industry Division
801 West Badger Road
P.O. Box 8911
Madison, WI 53708
(608) 266–7135

Poison Control Centers

A nationwide network of poison control centers has been established with the assistance of the Food and Drug Administration, U.S. Department of Health and Human Services. Most of these centers are affiliated with local hospitals, and their staff members are specially trained in the treatment of poison cases.

This list, current to October 1982, is supplied by the Director of the Division of Poison Control, 5600 Fishers Lane, Rockville, MD 20857, (301) 443–6260.

Maine

State Coordinator
Maine Poison Control Center
Portland, ME 04102
(207) 871–2950

Maine Medical Center
Emergency Division
22 Bramhall St.
Portland, ME 04102
(207) 871–2381
(800) 442–6305 (Statewide)

Michigan

State Coordinator
Department of Public Health
Emergency Medical Services
Lansing, MI 48909
(517) 373–1406

Marquette General Hospital
420 W. Magnetic Drive
Marquette, MI 49855
(906) 228–9440
(800) 562–9781 (Northern Michigan)

Midland Hospital
4005 Orchard Drive
Midland, MI 48640
(517) 631–8100

Northern Michigan Hospitals, Inc.
416 Connable
Petoskey, MI 49770
(616) 347–0555

Poison Information Center
Munson Medical Center
Sixth Street
Traverse City, MI 49684
(616) 947–6140

Minnesota

State Coordinator
State Department of Health
717 S.E. Delaware Street
Minneapolis, MN 55404
(612) 623–5284

St. Luke's Hospital
Poison Control Center
915 East First Street
Duluth, MN 55805
(218) 726–5466

St. Mary's Hospital
407 East 3rd Street
Duluth, MN 55805
(218) 726–4500

St. Cloud Hospital
1406 6th Avenue, North
St. Cloud, MN 56301
(612) 255–5617

New Hampshire

State Coordinator
New Hampshire Poison Center
NH-Dartmouth Hitchcock
Medical Center
2 Maynard Street
Hanover, NH 03756
(603) 643–1000
(800) 562–8236 (Statewide)

New York

State Coordinator
Department of Health
Albany, NY 12237
(518) 474–3785

Glens Falls Hospital
100 Park Street
Glens Falls, NY 12801
(518) 761–5261

Ellis Hospital
1101 Nott Street
Schenectady, NY 12308
(518) 382–4039 or 4121

St. Luke's Memorial
Hospital Center
P.O. Box 479
Utica, NY 13502
(315) 798–6200

House of the Good
Samaritan Hospital
Washington and Pratt
Streets
Watertown, NY 13602
(315) 788–8700

Vermont

State Coordinator
Department of Health
Burlington, VT 05401
(802) 862–5701

Vermont Poison Center
Medical Center Hospital
Burlington, VT 05401
(802) 658–3456

Wisconsin

State Coordinator
Department of Health & Social
Services
Division of Health
Madison, WI 53701
(608) 267–7174

Luther Hospital
1225 Whipple
Eau Claire, WI 54701
(715) 835–1515

Green Bay Poison Center
St. Vincent Hospital
835 S. Van Buren Street
Green Bay, WI 54305
(414) 433–8100

Caution about Pesticides

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticide when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first-aid treatment given on the label, and get prompt medical attention. (See the list of Poison Control Centers on pages 27 to 28.) If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary landfill dump, or crush and bury them in a level, isolated place.